Four New Species, a New Genus, and a New Suborder of Hawaiian Fishes[1]

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THE DESCRIPTION of new taxa in a "Handbook of Hawaiian Fishes" recently submitted for publication was considered inadvisable. Certain of these are grouped together here, i. e., three new species of Gobiidae (*Quisquilius aureoviridis*, *Q. limbatosquamis*, and *Hazeus unisquamis*), a new genus and species of Callionymidae (*Pogonymus pogognathus*), and a new suborder of Perciformes (Schindlerioidei) erected for the fishes of the genus *Schindleria*.

Family GOBIIDAE, Genus QUISQUILIUS

The two new species of *Quisquilius* described below can be assigned to that genus with considerable assurance, as the type species, *Q. eugenius*, is another Hawaiian form of which numerous specimens are available. The characteristics listed in the following paragraph are held in common by the two new species and *Q. eugenius*.

No hairlike or flaplike appendages on the head or shoulder girdle. No serrations or spines on the preopercle. Maxillary not prolonged posteriorly. No V-shaped notch in the tip of the lower jaw. No teeth on the vomer. Teeth in both jaws in several rows, those of the outer and inner rows enlarged and spaced at intervals. One or two fanglike teeth in the outer row at each anterolateral angle of the lower jaw. Tongue usually with a slight to broad notch in the tip. Cleft of the mouth more or less oblique. Both nostrils in tubes, the anterior at least twice as far from the posterior as from the groove behind the upper lip. No pores on the head. The rows of papillae (not shown in Fig. 2) are in very uniform alignment. There is one pair on the posterior portion of the interorbital and two rows of about 5 papillae each on the flesh covering the premaxillary pedicels. A series of about 5 large, widely spaced papillae borders the orbit below. A row or pair of rows runs backward from the eye just above the upper border of the opercle. Two horizontal rows on cheek, the upper sometimes extending all the way across but the lower ending on middle of cheek. A verticle row down front of operculum with two branches running back or down and back from it. One or two rows along the lower border of the preopercle. One row of papillae above and two below enclose the corner of the mouth. Two rows on the gular membrane, one on each side. Gill openings extending down to below the preopercular border, the distance between their lower ends equal to or less than an eye diameter. Ten or more developed gill rakers on the lower limb of the outer arch. Scales ctenoid, those on the body not especially enlarged posteriorly. Scales on top of head extending forward nearly to eyes, but no enlarged scales just behind eyes. First dorsal fin with 6 spines. First spine in both dorsal fins with a flexible tip. Caudal rounded, not longer than the head length. Pectoral without silky rays above. The united pelvics without a basal frenum, the membranes uniting the inner rays easily torn (as it apparently was in the holotype of *Q. eugenius*).

Examination of numerous specimens of *Q. eugenius*, 15 to 45 mm. in standard length, indicates no great sexual dimorphism. Over the available size range there is also no great differentiation in sensory papilla pattern. However, the cheek squamation does not appear until well after all of the other scales have formed.

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Among Hawaiian gobies *Zonogobius* (as represented by *Z. farcimen*) seems to be the closest relative. These two genera are set off from other Hawaiian gobies by the following features: no pelvic frenum; two longitudinal series of papillae on the flesh covering the premaxillary pedicels; and 10 or more developed gill rakers.

Of the three Hawaiian species of *Quisquilius*, *Q. eugenius* is an abundant shallow-water fish inhabiting areas of dead coral. It seems to be restricted to depths of less than 15 feet. The other two species are in general deeper-water forms, though the type of *Q. aureoviridis* was collected in a tide pool with a maximum depth of 7 feet.

Quisquilius aureoviridis sp. nov.
Fig. 1, Table 1

HOLOTYPE: USNM 175013, 37.1 mm. in standard length taken in a rotenone station at Pupukea, Oahu, Territory of Hawaii by Gosline, *et al.*, Dec. 23, 1949.

PARATYPES: USNM 175014, 1 specimen, 36.2 mm., about 1 mi. north of Kailua, Hawaii, T. H., Gosline, *et al.*, June 19, 1953; University of Hawaii No. 1703, 8 specimens, 21.0–27.2 mm., off Waikiki reef, Oahu, T. H., Gosline, *et al.*, Dec. 31, 1952.

Depth of body contained about 4 times in the standard length.

Head somewhat wider than deep, its greatest depth contained about 1.5 times in the head length. Mouth oblique, the lower jaw protruding. Front of mouth about on a level with the middle of pupil; rear of jaw about reaching to below front border of pupil. Eye bordered by a shallow groove posterodorsally, its diameter contained about 4 times in head in a 2-inch specimen. Least distance between eye and groove behind upper lip contained a little over 2 times in the eye diameter. Anterior nostril placed just above the groove behind upper lip, the posterior above the level of the top of pupil. Interorbital gently concave, not in a deep trench between the eyeballs, its width contained about 4 times in the eye diameter. Thirteen moderate, pectinate gill rakers on the lower limb of the outer arch in one specimen. Tongue rounded but usually with a central notch at tip.

Body completely scaled, those scales above the pectoral base rather irregularly placed. A few scattered rows of papillae crossing certain of the body scales. Head scaled forward to the groove behind each eye. No scales on cheek or operculum. Thirty to 33 scales in a longitudinal series, 9 or 10 in a transverse series; about 13 predorsal scales.

Some of the spines in the first dorsal filamentous. Second dorsal with a spine and 10 or 11 soft rays. Anal with a spine and 8 or 9 soft rays. Pectoral with about 19 rays.

TABLE 1
CERTAIN COUNTS IN THREE HAWAIIAN SPECIES OF *Quisquilius*

SPECIES	LATERAL LINE SCALES*								TRANSVERSE SCALE ROWS†					TOTAL 2ND DORSAL RAYS				TOTAL ANAL RAYS		
	26	27	28	29	30	31	32	33	7	8	9	10	11	10	11	12	13	9	10	11
Q. eugenius		1	1	3							2	2	1			4	1	1	3	1
Q. aureoviridis																				
Holotype								1				1				1			1	
Paratypes				1	1	1		1			3	2			2	3		3	2	
Q. limbatosquamis																				
Holotype		1							1						1			1		
Paratypes	2	4							3	3				6				5	1	

* Counted from the upper angle of the gill opening to the crease at the end of the hypural fan.
† Counted from the beginning of the anal upward and forward to the dorsal base.

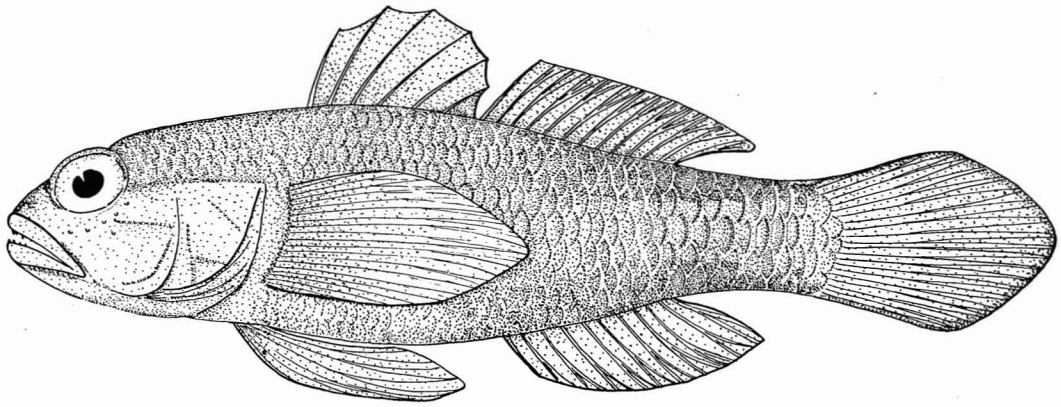

FIG. 1. *Quisquilius aureoviridis*, holotype.

Color in life yellowish green to yellowish brown with faint slightly darker vertical bars. In alcohol a broad, lighter longitudinal bar becomes apparent along the middle of the body posteriorly. Fins light or dusky. Small specimens show traces of dark vertical bars on the head.

Quisquilius aureoviridis differs from *Q. eugenius* most notably in interorbital structure. In the latter species the eyes are raised, leaving a deep, narrow trench between them, the bottom of which is hardly visible; in *Q. aureoviridis* the eyes are little raised above the level of the relatively broad interorbital. In *Q. eugenius* the scales on the cheek and opercle are prominent in adults; in *Q. aureoviridis* they are absent. Finally, the two species may at once be separated in life by coloration, for *Q. eugenius* is a brownish black with vertical stripes.

Koumans (1953: 131) has synonymized four other species with *Q. eugenius*. Of these, three at least—*Q. cinctus*, *Q. naraharae*, and *Q. profundus*—do not seem to belong there. They appear, on the contrary, to be somewhat nearer *Q. aureoviridis* at least in the lack of squamation on the cheek and (usually) on the operculum. All of them differ from *Q. aureoviridis*, however, in having the body dark with light bands and in the punctate soft dorsal and anal fins.

Quisquilius malayanus and *Q. macrophthalmus* appear to be relatively large scaled forms, as is the species described below.

Aureoviridis = (L.) yellow green.

Quisquilius limbatosquamis sp. nov.
Fig. 2, Table 1

HOLOTYPE: USNM 175012, 20.0 mm. in standard length, taken in a rotenone station about 2 mi. west of Haleiwa, Oahu, Territory of Hawaii by Gosline, *et al.*, July 23, 1955.

PARATYPES: University of Hawaii No. 1704, 8 specimens, 15.6–18.5 mm., off Waikiki reef, Oahu, T. H., Gosline, *et al.*, Dec. 31, 1952.

Depth of body contained 4.5 times in the standard length.

Greatest width of head considerably greater than greatest depth of head, the latter contained about 1.9 times in the head length. Mouth oblique, the lower jaw protruding. Front of mouth about on level with center of pupil. Rear of jaw below front of pupil. Eye not surrounded by a recessed groove above or posteriorly, its diameter contained about 3.7 times in the head length. Smallest distance between eye and groove behind upper lip contained about 2.5 times in the eye diameter. Anterior nostril about ⅓ as far from the groove behind upper lip as from the posterior nostril. Posterior nostril slightly above top of pupil. Interorbital narrow, not in a deep recess, its width contained perhaps 5 times in

the eye diameter. No pores on head. Rows of papillae on head less markedly developed than in *Q. aureoviridis*. Ten gill rakers on the outside row of the lower limb of the first arch. Pseudobranch composed of 4 lobes. Tongue as seen from below rounded but with a slight indentation in middle.

Body completely scaled except apparently on the middorsal ridge that runs about one eye diameter forward from the first dorsal fin. Head scaled forward to an imaginary line drawn across between the rear of the orbits. Cheek and opercle scaleless. Twenty-six or 27 scales in a longitudinal series; 7 or 8 transverse rows; predorsal scale row incomplete. Scales ctenoid, except perhaps for those on breast.

None of the dorsal spines filamentous. Membrane between the two dorsals not quite connecting them. Second dorsal with a spine and 9 or 10 rays. Anal with a spine and 8 rays. Pectoral 19 or 20.

Color light with a light, dark-bordered vertical band crossing the nape and enclosing the pectoral base. Behind this are 6 vague dark vertical bands, one of these at caudal base, the others darkest on the middorsal and midventral lines. Each scale on the body completely and prominently outlined by a series of large melanophores. Dorsal fins, particularly the first, with dark smudges at the base of the rays. Soft dorsal rays speckled. Head with traces of 3 broad vertical bands running down cheek and operculum.

This species was taken along with *Quisquilius aureoviridis*. It resembles that species rather than *Q. eugenius* in that the orbits are not partially enclosed in a deep trench and in the absence of scales on the cheek and head. However, *Q. limbatosquamis* differs from both the other Hawaiian species of the genus in the somewhat flatter head, in having a triangular naked area on the top of the head between and behind the eyes, in having a naked ridge extending forward from the first dorsal, in the larger scales and fewer dorsal rays. In color *Q. limbatosquamis* differs from the other two in having each of the scales distinctly outlined by a series of melanophores.

Of other described species *Q. limbatosquamis* seems to differ from *Q. malayanus* in color and from *Q. macrophthalmus* in the far higher pectoral count.

Limbatosquamis = (L.) edged scale.

Family GOBIIDAE, Genus HAZEUS

The relationships of the fish described below are most obscure, at least to the present author. It has been placed in the genus *Hazeus* because nothing better could be found. As one source of confusion this author has never seen the type species of *Hazeus*, *H. otakii* Jordan and Snyder (1902: 51, fig. 3). As another, the genus has frequently been considered a synonym of *Gnatholepis*, e.g., by Jordan and Evermann (1905: 487) and by Koumans (1931: 86; 1953: 168), but until it can be determined what fish *G. anjerensis*, the type species of *Gnatholepis*, represents there can be no final decision on the matter.

Hazeus unisquamis sp. nov.
Fig. 3

HOLOTYPE: USNM 175009, 18.2 mm. in standard length, taken by means of rotenone in a cut in the reef about 200 yds. west of Diamond Head, Oahu, Territory of Hawaii, by Gosline and class, May 16, 1950.

Depth of body contained 4 times in the standard length. Depth of caudal peduncle contained about 2.5 times in its length.

Head considerably wider than deep, the greatest depth of head contained about 1.4 times in the head length. Cleft of mouth broad and very slightly oblique, the lower jaw somewhat projecting. Front of mouth about on a level with lower border of pupil; maxillary reaching to below middle of eye. Upper lip narrow, its greatest width somewhat less than that of lower lip. Eye directed superolaterally, its diameter contained about 2.2 times in the head length. Smallest distance between eye and groove behind upper lip contained about 4 times in the eye diameter. Both

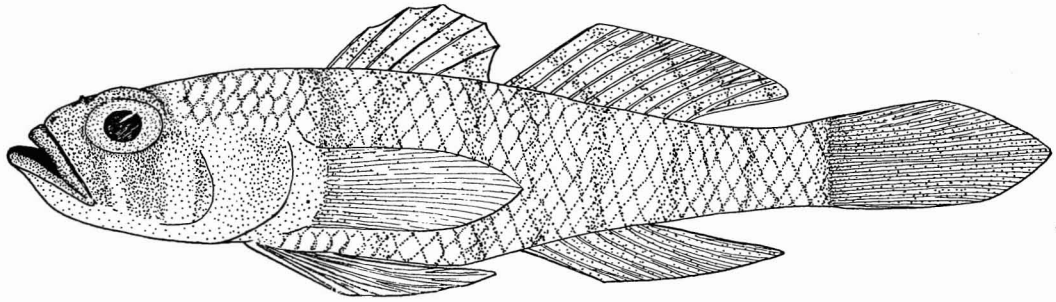

FIG. 2. *Quisquilius limbatosquamis*, holotype.

nostrils bordered by a low, raised collar, the anterior slightly nearer the posterior than the groove behind upper lip. Interorbital very narrow, hidden in a groove between the raised orbital borders. No pores on the head. Superior borders of orbit raised in a series of low flaps, these bordered behind by a groove; behind the interorbital region this groove is also bordered on the side away from the eye by a series of raised, scalelike flaps. No papillae on top of head, snout, or around eye, but two rows following the lower portion of the preopercular border and extending forward below the ramus of the lower jaw; another weakly developed vertical row on anterior portion of operculum. Gill cover free from the isthmus, the gill openings extending far forward about to below front of pupil. Ten widely spaced, pectinate gill rakers on the lower limb of the outer arch. Pseudobranch consisting of 5 lobes. Tongue with a broad, shallow median indentation as seen from below. Teeth in a narrow band in both jaws, some of the teeth on the inner border of the band somewhat enlarged; none of the outer teeth in either jaw especially enlarged.

Top of head scaled forward to the eye. Operculum almost completely covered by about 12 large, ctenoid scales. A single, large, embedded scale on the upper portion of each cheek. Twenty-six scales in a longitudinal series from above the upper end of the gill cover to the base of the caudal; 6 scales in a transverse series. Breast in front of pelvics without scales.

All of the fins with short, heavy rays maintained more or less erect. First spine in both dorsal fins more slender than the succeeding rays and with a soft tip. Dorsal VI-I,7. Anal I,7. Pectoral without silky rays above, with 18 rays in all; the upper 11 rays branched, the lower 7 simple, swollen and extending somewhat beyond the interradial membranes. Pelvics united, with a thin, smooth-edged frenum anteriorly.

In alcohol the only prominent marks are narrow black borders to the two dorsal fins and a blackish bar across the caudal peduncle just in front of the caudal base; chromatophores are scattered more or less evenly over the rest of the body and head, giving a plain gray ground color.

So far as I can see from the species descriptions available to me *Hazeus unisquamis* may be differentiated from related forms by having only a single scale on the cheek, dark borders to the two dorsal fins, and only 7 soft rays in the dorsal and anal.

Unisquamis = (L.) one scale, in reference to the single cheek scale.

Family CALLIONYMIDAE

POGONYMUS gen. nov.

TYPE SPECIES: *Pogonymus pogognathus* sp. nov.

Head and body depressed forward of the anal origin, compressed posteriorly. Head flat above, the eyes completely separated by a slightly concave interorbital area. No supraorbital tentacle. Preopercular process with an

upturned tip and with one additional dorsally directed spine ahead of tip; without an antrorse spine on its outer surface. Gill opening a small hole beneath the dorsal portion of the well-developed opercular flap. Lower jaw included, without a reverted lip but with a fringe of about 12 to 16 forwardly projecting papillae the tips of which extend beyond the upper jaw when the mouth is closed. Teeth elongate, in one or a few rows in both jaws, those above pointing backward, those below projecting up and back. A single lateral line running along sides, without notable side branches except for one at the rear, which forms a saddle across the caudal peduncle. Two dorsal fins, the first very low, of 2, 3, or 4 spines none of which reach the second dorsal origin when the first dorsal is depressed. Rays of second dorsal unbranched except for the last. All of the anal rays branched at tip, except for the last, which is divided to the base. Pelvic fins without separated rays and not attached to the middle of the pectoral fins by a membrane.

Judging from the keys to callionymid genera given by Schultz and Woods (1948: 419–420) and others, *Pogonymus* is most closely related to *Eleutherochir*. It differs from that genus and most other callionymids in the presence of a fringe of papillae on the lower jaw and in having the anal, but not the soft dorsal, rays divided at the tips.

Pogon = (Gr.) beard; onyma = (Gr.) name.

Pogonymus pogognathus sp. nov.
Fig. 4

HOLOTYPE: USNM 175010, a nearly ripe female 25 mm. in standard length, taken in 3 to 10 ft. of water in a small cove just west of Hanalei Bay, Kauai, Territory of Hawaii, by Gosline and Ohai, June 19, 1952.

PARATYPES: USNM 175011, 5 specimens, 15–21 mm.; University of Hawaii No. 1626, 34 specimens, 11–22 mm., all with the same data as the holotype.

Head broad and flat, its greatest depth contained about 1.6 times in its greatest width, which in turn is contained about 1.2 times in the head length to the end of the opercular flap. Eyes large, contained about 4 times in the head length, not projecting above the dorsal surface of the head, separated by a bony interorbital that is about equal to a pupil diameter in width and that contains two median pores. Snout broad and blunt, its length about ⅔ an eye diameter. Gape nearly twice as broad as deep, the maxillary reaching about to the anterior border of the eye when the mouth is closed. Gill covers attached to one another below by a free fold across the isthmus.

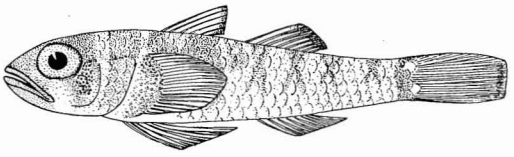

FIG. 3. *Hazeus unisquamis*, holotype.

Lateral line dropping down to the midsides about at the pectoral tip, giving rise to about 15 pores along its length, some of these slightly above the lateral line and others slightly below; terminating posteriorly about halfway out along the caudal rays.

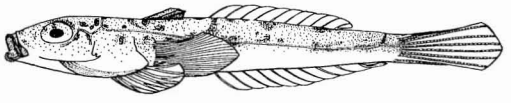

FIG. 4. *Pogonymus pogognathus*, paratype.

First dorsal originating about ⅓ of the way back along the standard length, its rays low and rather tightly bound to the midline of the back by the membrane behind the last ray. Longest dorsal spine considerably shorter than the distance between dorsal fins. Soft dorsal with 9 or 10 rays, lying somewhat ahead of anal, its last ray not nearly reaching caudal base when depressed. Anal with 9 or 10 rays, the tip of the last about reaching caudal base.

Caudal fin slightly shorter than the head length, with 6 principal rays, all of which are somewhat branched at tip, the outermost least so; 10 caudal rays in all, the outermost short, splintlike, and unsegmented. Pelvic fins with a spine and 5 branched rays, the fourth of which is the longest. Pectoral with about 19 rays, the longest of which reach about to above the anal origin.

A 15 mm. (standard length) specimen has black spots at the base of each soft dorsal and anal ray and another at the base of tail. Between 15 and 20 mm. these markings fade, so that the specimens are a plain yellowish brown except for some incipient markings on the back and on the first dorsal. At a length of 25 mm. the first dorsal is almost completely black, and there are prominent dark bars and spots symmetrically arranged on either side of the middorsal line on the body and head.

The three specimens sexed, 22 to 25 mm. in standard length, proved to be nearly ripe females. If adult males are represented among the types, they show no striking external differences.

The species has been taken only once. This was from a poison station run in a small, semi-protected cove in which a vertical, alga-covered ledge dropped vertically to a uniform sand bottom 3 to 10 feet below. *Pogonymus pogognathus* was the most abundant species taken. Whether the individuals were living on the ledge or in the sand below (as seems more probable judging from the fringed lip) was not verified at the time. Just how this habitat differed from that of innumerable other poison stations run from ledges dropping off to a sand bottom remains unknown to the author.

Pogon = (Gr.) bearded; gnathos = (Gr.) jaw.

Suborder SCHINDLERIOIDEI

The two known species of *Schindleria* (see Fig. 5) were first described as members of the genus *Hemiramphus* in the 1930's. They have been bounced about from order to order ever since. The members of the genus are neotenic

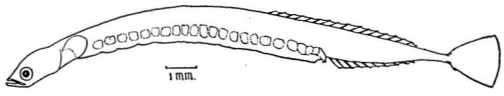

FIG. 5. *Schindleria praematurus*, female with eggs. (After Bruun.)

fishes, apparently without close relatives, which have lost the adult characteristics that would presumably indicate their relationships. The present erection of a new suborder of perciform fishes for *Schindleria* is not made on the basis of any decisive new material; it merely seems to be the best available solution to a difficult problem. Knowledge of *Schindleria* may be marshaled under four heads: neoteny, sexual differentiation, soft anatomy, and "osteology." These will be dealt with only in so far as they bear on the systematic position of the genus.

Neoteny: That a 20 mm. *Schindleria* may be sexually mature is often indicated by the conspicuous presence of large eggs in the females. That the rest of the fish is in a larval stage of development is shown by the presence of the atrium directly behind, i.e., on the same horizontal plane with, the ventricle (Schindler, 1932: pl. 4c); by what is apparently a functional pronephros (Schindler, 1932: 25); by the well-developed opercular gill (Schindler, 1932: 12); the tremendous, protruding eyes; the rounded pectoral fin attached to a lobate, fleshy base; the transparent body; and by the degree and nature of the "ossification" of the skeleton (see below).

Neoteny in fishes is rare, and nowhere is it carried to the extreme found in *Schindleria*. It is also apparently sporadic, occurring as it does in some of the Clupeiformes (e.g., Salangidae), in at least one member of the Beloniformes (*Cololabis adocetus*), and perhaps in the gobioid Perciformes. Consequently, its neotenous nature is of no great aid in the systematic placement of *Schindleria*. One is merely inclined to ask the irrelevant question why neoteny does not occur more often among fishes of the open ocean.

Sexual Differentiation: Aside from the primary sex organs there is in the males (but not the females) of *Schindleria*, especially in *S. praematurus*, a long urogenital papilla (Schindler, 1932: 6, 8; Bruun, 1940: 7, fig. 2). In addition, the anus of both species lies farther back along the body in females than in males (Schindler, 1932: 6, 8; Bruun, 1940: 5).

Soft Anatomy: In 1932 Schindler described the soft parts of *Schindleria praematurus* with special reference to the heart, swim-bladder, gills, and the digestive and urogenital systems. None of the features described, nor the sexual differentiation, provides the present author with any clue as to the taxonomic relationships of the genus.

"Osteology": There is some difficulty in determining what should be included under "osteology." Schindler (1932: 6) states: "An ossification or deposit of lime in the vertebrae is not present." However, the vertebrae take up alizarin stain. In the account of the osteology that follows all those portions that stain with alizarin will be considered "ossifications."

As the final comment in his paper on *Schindleria*, Giltay (1934: 10) has said: "Des matériaux plus nombreux nous permettront de mieux définir ses affinités, surtout quand on aura mieux pu étudier le squellette qui est deja relativement bien développé." There are several difficulties with this proposition. First, additional material has been gathered and it has not helped much. Second, the degree of ossification in the additional specimens is about the same as in those taken earlier, and there seems little hope of finding an adult-type ossification in *Schindleria*. Third, the "ossification" that is present occurs to approximately the same extent and in about the same areas as in a larval anchovy of the same size. To what extent this larval-type ossification in *Schindleria* is comparable to the bony structure of other adult fishes is an open question. (In this author's opinion, the "ossifications" that do occur in *Schindleria* are not of an adult fish type at all but are merely calcifications of normally larval structures. Indeed, it seems that the adult *Schindleria* has retained larval features which have to some extent "ossified" precociously as compared to the ontogenetic development of the same features in normal fishes. If this is true, the calcifications in *Schindleria* bear little comparison with normal adult fishes and are only incompletely comparable with any larval stage.)

Judging from the absorbtion of alizarin stain, the jaws, vertebral centra, and fin rays are the best ossified portions of *Schindleria*. The upper jaw consists of a toothed premaxillary and a toothless maxillary of about equal length (Fig. 6a). The premaxillary has an upwardly projecting flange a little more than halfway out. The premaxillary pedicel is broad and low, articulating medially with a large cartilaginous (?) median pad and laterally with the maxillary. The latter bone has an abrupt, sharp-angled bend (Fig. 6b) that hooks around the premaxillary pedicel; the bone then projects medially inside the pedicel.

The lower jaw consists, so far as can be determined, of a single ossification (Fig. 6e), though an obscure "suture" between dentary and articular may have been missed.

The suspensorium runs very obliquely forward in order to pass below the very large eye (Fig. 6c) between the skull and the lower jaw. The only portion of the suspensorium that takes stain is a long splint made up of the quadrate below and the hyomandibular above (Fig. 6e). From the rear of the hyomandibular projects an elongated, leaf-shaped operculum.

The hyoid apparatus (Fig. 6e) consists of a vaguely ossified glossohyal in front, an elongate ceratohyal, and an epihyal. The last bone loops around posteriorly to join the upper portion of the hyomandibular. There are 5 short branchiostegals; 2 on the ceratohyal and 3 on the epihyal. There are 4 gill arches (Schindler, 1932: 11); the lower pharyngeals are separate.

The forward portion of the cranium does not take up stain. To the rear above there are three small, partial ossifications which are here

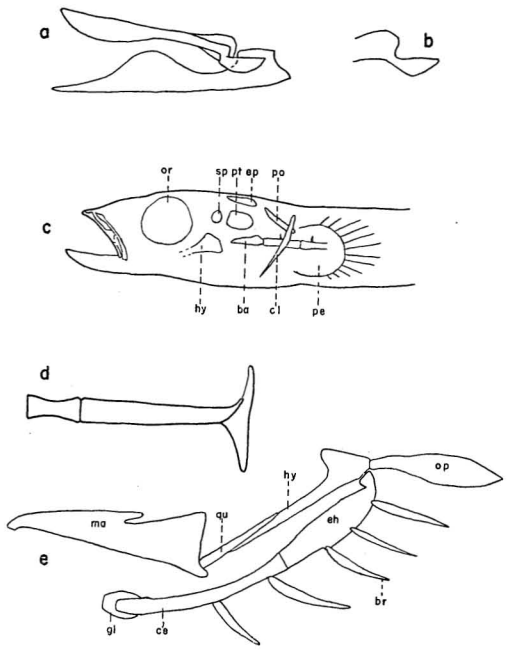

FIG. 6. *Schindleria*. a, Left premaxillary and maxillary from the inside, the posterior end of the maxillary somewhat raised. b, Median end of left maxillary from above. c, Head and fore part of body to show certain "ossifications." d, Caudal skeleton and posterior portion of "vertebral column." e, Mandible, suspensorium, opercle, and hyoid apparatus. ba, "Basioccipital"; br, branchiostegal ray; ce, ceratohyal; cl, cleithrum; eh, epihyal; ep, epiotic; gl, "glossohyal"; hy, hyomandibula; ma, mandible; op, opercle; or, orbit; pe, pectoral lobe; po, "posttemporal"; pt, pterotic; qu, quadrate; and sp, sphenotic.

provisionally identified as epiotic, sphenotic, and pterotic. Running in under the skull is a projection of the vertebral column which may represent the basioccipital (Fig. 6c); a possible alternate interpretation of this "bone" is suggested below.

The pectoral girdle consists of two simple struts (Fig. 6c) representing the cleithrum and probably the posttemporal. There is nothing in the fleshy lobe between the cleithrum and the pectoral rays that absorbs alizarin stain.

The vertebral centra stain clearly but the neural and haemal arches seem to be represented only by short spines that ride on the centra. The number of differentiated vertebrae vary from 33 to 39 in the genus (Schindler, 1932: 6, 8). At the rear of the vertebral column is a rodlike structure with an upturned tip that runs for the length of about 3 normal vertebrae. To its posterolateral face is attached a plate (Fig. 6d). Both of these features take stain well.

Since it is this terminal portion of the axial skeleton that forms the feature of *Schindleria* unique among all known fishes, some discussion of it seems in order. The terminal plate would appear to take the place of the hypural fan, differing from the usual caudal skeleton in the complete lack of separate ossifications. The rodlike portion of the "vertebral column" ahead of it is difficult to interpret satisfactorily. When the vertebral column first ossifies in an anchovy, the caudal portion of the column forms early as a number of small elements which eventually fuse to a considerable extent to form the adult caudal skeleton. One presumes that the tail rod of *Schindleria* evolved in a different ontogenetic fashion. The most satisfactory explanation for it that the author can find is that it represents the posterior portion of the notochord which has been replaced by cartilage and/or bone without dividing into discrete vertebral segments.

In this connection it is necessary to revert to the skull bone that was provisionally called the basioccipital in earlier paragraphs. The alternative explanation is that it is the forward end of this same notochord which has taken up stain in the same way suggested for the posterior rod.

In the caudal fin there are 13 rays, 11 of which are branched. The interneurals and interhaemals of the dorsal and anal fins respectively bear a one-to-one relationship with the vertebrae (see Bruun, 1940, fig. 2). There are from 15 to 20 unbranched dorsal rays, and from 11 to 17 unbranched rays in the anal; the pectoral contains 15 to 17 rays (Schindler, 1932: 7, 8).

Relationships: As mentioned, *Schindleria* was first described as a neotenic *Hemiramphus*.

Giltay (1934) demonstrated the incorrectness of this allocation. *Inter alia*, *Schindleria* differs from all of the Beloniformes in the low number of branchiostegal rays, the absence of fused pharyngeals, and the one-to-one relationship between dorsal or anal fin rays and vertebrae.

A rather better case could be made for placing *Schindleria* in the Syngnathiformes or Gasterosteiformes. However, the Syngnathiformes are characterized by having the first 3 to 6 vertebrae immovably united. The lack of a tubular snout, of external bony plates, and of a soft dorsal fin with closely spaced rays argues against placing *Schindleria* in either of these orders.

Turning from negative to positive indications of relationships, there appears to be only one character in *Schindleria* which provides any clues. This is, as already noted by Giltay (1934), the one-to-one relationship between the dorsal or anal fin rays and the vertebrae. It appears that this characteristic is limited to the Perciformes, being found there in the trachinoid, ammodytoid, blennioid, and many of the gobioid fishes. However, the basal perciform stock has, like other fishes, two or three soft dorsal and anal rays (with their interneurals and interhaemals) per vertebra. Just why certain perciform groups should have a one-to-one relationship between these features remains unknown. That it is a polyphyletic development is shown by the gobioid fishes, where this relationship seems to have developed within the group itself. At least, *Ptereleotris* has the usual two or three interneurals per vertebrae whereas most of the other gobioids have only one (Gosline, 1955: 166). If the one-to-one relationship has occurred several times within the perciform fishes, could it not also occur within other orders? The best available answer to this question seems to be that it apparently has not done so.

To sum up regarding the ordinal position of *Schindleria*, the genus seems to rest most easily (or rather least uneasily) among the Perciformes. There is nothing to really invalidate such a position and there is the one-to-one fin ray to vertebra relationship to recommend it. Where *Schindleria* belongs among the Perciformes is obscure. The best that can be done is to place *Schindleria* in the neighborhood of the blennioid fishes.

The reason for raising *Schindleria* to subordinal rank (rather than placing it in the Blennioidei as Giltay, 1934, has done) lies in the rodlike terminal section of the spinal column. There seems to be nothing like it elsewhere in fishes. The author has looked through the literature on both adult and larval fishes without finding anything similar. He has discussed this precaudal rod with E. A. Ahlstrom, A. F. Bruun, and C. L. Hubbs, and wishes to thank them for their help on this matter; nevertheless, nothing resembling this rod has come to light. In the great majority of modern fishes the notochord is replaced by vertebrae. However, when this occurs the vertebral replacement runs all the way back to the caudal skeleton. The uniqueness of *Schindleria* lies in the fact that vertebral development stops short some distance before the caudal skeleton.

There is one other feature of *Schindleria* that this author has never encountered elsewhere in fishes or in the literature (although this may simply indicate a gap in the author's knowledge, especially in regard to larval fishes). In *Schindleria* the hyoid apparatus (Fig. 6) articulates with the upper head of the hyomandibular. In all the fishes the author knows, the hyoid apparatus articulates by means of the interhyal at the lower extremity of the hyomandibular.

REFERENCES

BRUUN, A. F. 1940. *A Study of a Collection of the Fish* Schindleria *from South Pacific Waters.* Dana Report 21. 12 pp., 8 figs.

GILTAY, L. 1934. *Notes ichthyologiques. VIII. Les larves de Schindler sont-elles des Hemirhamphidae?* Mus. Roy. d'Hist. Nat. de Belgique, Bul. 10, no. 13. 10 pp., 4 figs.

GOSLINE, W. A. 1955. The osteology and relationships of certain gobioid fishes, with particular reference to the genera *Kraemeria* and *Microdesmus*. *Pacific Sci.* 9(2): 158–170, figs. 1–7.

JORDAN, D. S., and B. W. EVERMANN. 1905. *The Aquatic Resources of the Hawaiian Islands. Part I. The Shore Fishes.* U. S. Bur. Fisheries, Bul. for 1903, Vol. 23. Pp. 574, 1 map, 65 pls., 73 col. pls.

JORDAN, D. S., and J. O. SNYDER. 1902. A review of the gobioid fishes of Japan, with descriptions of twenty-one new species. *U. S. Natl. Mus., Proc.* 24: 33–132, figs. 1–33.

KOUMANS, F. P. 1931. *A Preliminary Revision of the Genera of the Gobioid Fishes with United Ventral Fins.* Leiden.

——— 1953. *The Fishes of the Indo-Australian Archipelago.* Vol. 10. E. J. Brill, Leiden.

SCHINDLER, O. 1932. *Sexually Mature Larval Hemiramphidae from the Hawaiian Islands.* Bernice P. Bishop Mus. Bul. 97. 28 pp., 10 pls.

SCHULTZ, L. P., and L. P. WOODS. 1948. A new name for *Synchiropus altivelis* Regan, with a key to the genera of the fish family Callionymidae. *Wash. Acad. Sci., Jour.* 38: 419–420.